Rocky Mountain
Remediation Services, L L C
protecting the environment

PROCEDURE

WELL DEVELOPMENT

Procedure No RMRS/OPS PRO 106
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Manager Water Operations Waste Operations Division — Date

USE CATEGORY 2

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1 0 PURPOSE

This document contains guidelines for the development of new wells and piezometers at the Rocky Flats Environmental Technology Site (RFETS) These procedures also apply to the redevelopment of pre-existing wells or piezometers by removing sediment or other built-up material The objective of a completed well development activity is to provide groundwater inflow that is as physically and chemically representative as possible of the aquifer that is open to the well or piezometer

2 0 SCOPE

This document, which supersedes groundwater SOP GW 02 applies to all Rocky Mountain Remediation Services (RMRS) personnel and subcontractors conducting groundwater-related work at the RFETS This document, which constitutes a Standard Operating Procedure (SOP) describes acceptable methods for the development or re-development of wells and piezometers installed at RFETS

3 0 REQUIREMENTS

The following sections identify the personnel qualifications and equipment for the development of wells and piezometers at RFETS

3 1 Personnel Qualifications

Personnel performing these procedures are required to have completed the initial 40-hour OSHA classroom training that meets Department of Labor Regulation 29 CFR 1910 120(e)(3)(i), and must maintain a current training status by completing the appropriate 8-hour OSHA refresher courses Personnel must also have read and signed the appropriate Health and Safety Plan(s)

Prior to engaging in well or piezometer activities, personnel are required to have a complete understanding of the procedures described within this and other related SOPs and receive specific training regarding these procedures if necessary

3 2 Equipment

The following is a list of basic equipment typically required when developing wells or piezometers Additional equipment may be required in less typical applications and will be specified in the project-specific work plan or other appropriate document.

- Stainless steel or Teflon® bailer
- Mechanical reel equipped with a stainless steel Teflon® coated cable
- Inertial pump
- Peristaltic pump
- Water parameter test kit (see SOP RMRS/OPS-PRO 108 Measurement of Groundwater Field Parameters)
- Wash/Rinse tubs
- Clear plastic sheeting or vinyl sheeting which may be decontaminated
- Liquinox detergent
- Containers for development water (see SOP RMRS/OPS-PRO 128, Handling of Purge and Development Water)

- Electronic water level sounder (see SOP RMRS/OPS PRO 105 Water Level Measurements in Wells and Piezometers)
- Distilled or deionized water
- Field book and field forms
- Health and safety equipment and supplies
- Organic vapor detector (OVD)
- Calculator
- Black water proof pens

4.0 INSTRUCTIONS

Monitoring well development is the process by which the well drilling fluids and mobile particulates are removed from within and adjacent to the newly installed wells and piezometers This process can also be used to remove sediment or other built up material from an older well The objective of a completed well development activity is to provide groundwater inflow that is as physically and chemically representative as possible of the aquifer that is open to the piezometer or well

4.1 DEVELOPMENT PROCEDURES

4.1.1 *New Wells and Piezometers*

Perform the development as soon as practical after well or piezometer installation but no sooner than 48 hours after grouting and pad installation is completed These new wells and piezometers will be developed utilizing low energy methods The equipment of choice for well development is an inertial pump or bottom discharge/filling bailer Piezometers will be developed using either a small diameter Teflon® or stainless steel bailer or a peristaltic pump High-energy methods such as submersible pumps surge blocks overpumping backwashing and well jetting will generally not be used due to the possibility of formation fines clogging the well screen unless otherwise specified in the project work plan or sample and analysis plan

New wells that are installed in areas known to be contaminated with organics (e g volatile organic compounds) or which cause a positive reading on the OVD will be checked for the presence of immiscible layers prior to well development The method for detecting these layers in monitoring wells is discussed in SOP RMRS/OPS PRO 105 Water Level Measurements in Wells and Piezometers If an immiscible layer of 5 mm or greater has been detected in a newly installed well, well development procedures will not continue until the RMRS project manager has been notified In the case where an immiscible layer is not identified, a water level measurement will be taken according to SOP RMRS/OPS PRO 105 Water Level Measurements in Wells and Piezometers and well development activities will continue The water level measurement along with the total depth measurement will be used to determine the volume of water in the well casing Well casing calculations are presented in Subsection

4 1 1 1 of this SOP

For wells formation water and fines will be evacuated by slowly lowering and raising the inertial pump or bailer intake throughout the water column The inertial pump may be placed inside a decontaminated 1 inch diameter PVC pipe if the pump intake cannot be lowered to the bottom of the well The PVC pipe will prevent the inertial pump intake from bending prior to reaching the desired depth RMRS personnel will determine whether an inertial pump will be dedicated to a specific well based on verified organic vapor detector (OVD) readings obtained during the drilling of the well OVD readings are described in SOP FO 15, Photoionization Detectors (PIDs) and Flame Ionizing Detectors (FIDs) If a bailer is used for well development, it will be used with a mechanical reel equipped with a stainless steel Teflon® coated cable Development equipment will be protected from the ground surface with clear plastic sheeting Development equipment, including bailers and pumps, will be decontaminated before well development begins and between well sites according to SOP RMRS/OPS-PRO 127, Field Decontamination Operations

For small diameter piezometers the formation water and fines will be evacuated by slowly lowering and raising the peristaltic pump intake tubing or bailer throughout the water column If a peristaltic pump is used, it will be fitted with chemically inert silicon or equivalent type tubing for the intake and discharge lines If a bailer is used for well development, it will be used with a mechanical reel equipped with a stainless steel Teflon® coated cable Development equipment will be protected from the ground surface with clear plastic sheeting Development equipment, including bailers and pumps, will be decontaminated before well development begins and between well sites according to SOP RMRS/OPS-PRO 127, Field Decontamination Operations

Estimated recharge rates will be measured in wells and piezometers that dewater following the procedures outlined in SOP RMRS/OPS-PRO 105, Water Level Measurements in Well and Piezometers Decontamination and development water will be handled according to SOP RMRS/OPS-PRO 112, Handling of Decontamination Water and Wash Water and SOP RMRS/OPS-PRO 128, Handling of Purge and Development Water respectively

4 1 1 1 Development Criteria for New Wells

Development shall proceed in the manner described herein and continue until the following are met.

- Removal of a minimum of five well casing volumes Typical well casing volume calculations include

  a. 0 75-inch inside diameter well
  87 milliliters/ft x___(linear ft. of water) = ml of water

  b 2-inch inside diameter well.
  0 16 gal/ft x __(linear ft of water) = gallons of water

c 4 inch inside diameter well

0 64 gal/ft x ___ (linear ft of water) = gallons of water

Graduated containers will be used to measure the amount of water removed

1 If the initial water measurement (WLM) indicates water is at a depth below the bottom of the screened interval the well is considered technically dry for development purposes Most wells installed after 1991 are constructed with a sump that is approximately 2 feet deep Piezometers that are less than 2 inches in diameter will have sumps of that vary in length If a well is dry or technically dry it is recommended (but optional) that monthly water level measurements be taken for one year to check seasonal changes in the water table A well can be developed following a WLM which indicates the well is not dry (water covering all or a portion of the screened interval)

2 When a well or piezometer dewaters during development, deionized (DI) or distilled water may be added to the well Prior to the addition of the water a recharge rate will be established using a 10 minute recharge period and extrapolated to a 30 minute recharge period If the recharge rate will allow for evacuating the total volume needed to complete five volumes within 4 to 6 hours no water will be added If this condition does not exist, the following procedure is recommended The volume(s) of water to be added, herein known as screened interval volume(s) is calculated using the interval from the top of the screen to the bottom of the well (TD) When a well dewaters during development prior to evacuating the minimum five volumes the number of complete volumes evacuated will be counted and subtracted from the five volumes The number of volumes remaining will be calculated as screened interval and those volumes of DI or distilled water will be added to the well

An effective method for adding the distilled or DI water is to add one screened interval volume and begin pumping or bailing If using a pump located at the bottom of the well trickle the remaining volumes in at the rate of pumping This will keep water flowing across the entire screened interval to clean it Keeping the water level at the top of the screened interval by trickling the remaining volumes into the well minimizes the hydrostatic head on the well This reduces water loss to the formation Some fluid loss can be expected if any portion of the sand pack is dry (irretrievable water due to wetability of the sand) If the well is being developed by bailing, add one screened interval volume and bail down Continue this process until all the needed volumes have been added and evacuated Any water loss experienced should be noted on the well development form

3 When a monitoring well or piezometer has an initial water column that covers only a portion of the screened interval but does not dewater prior to evacuating the five minimum volumes no distilled or DI water will be added to the well

4 When the initial water column is greater than the height of the screened interval but dewaters prior to completion of development, DI water will be added according to procedures described in 2 above

5 All wells that measure technically dry initially will be bailed dry This procedure will remove or partially remove well construction water and the first monthly WLM will more accurately reflect any groundwater recharge

- A well or piezometer is considered successfully developed when consistent measurements of pH temperature, specific conductance and turbidity are recorded for the final three consecutive casing volumes evacuated from the well Consecutive readings are temperatures within 1°C pH readings within 0.2 units consecutive conductivity readings within 10 percent of each other and formazine turbidity units (FTU) within 10 percent of each other The requirement for temperature stabilization may be waived in cases where the reason for instability is related to limitations associated with the purging technique, such as limited volume of purge water combined with ambient air and purge equipment temperature extremes It is expected that this condition could exist at wells having less than 2000 ml in storage This variance must be documented with a full explanation on the Well Development/Redevelopment Log (Form PRO 106A)

- If water was used during drilling, the total fluid added will be recorded, and two times the fluid lost in the borehole during drilling will be recovered in addition to the five well casing volumes Additional purging will be required if, after removing the required volume, the field parameters have not stabilized. In this case, well development will continue until field parameter stabilization is achieved.

- The sediment in the well will be completely removed. The well will be checked for the accumulation of additional sediment one-week after initial development. Any additional sediment may be removed at the time of measurement.

- In low-yielding water-bearing formations, distilled or DI water may be introduced into the well to facilitate development. A volume of water equal to two times the volume of distilled water added to the well must be recovered from the well prior to ceasing development activities (if possible). If this is not possible, then a volume of water equal to that added to the well will be removed within eight hours Any deviations from the removal of the required volume of water will be recorded on the well development/redevelopment log (Form PRO 106A)

4 1 2 *Pre-Existing Wells and Piezometers*

Pre-existing monitoring wells and piezometers will be redeveloped in a manner similar to the well development of new wells and piezometers The equipment and procedures used for redevelopment will also be consistent with the

equipment and procedures used for the development of new wells

4 1 2 1 Redevelopment Criteria for Pre Existing Wells

The criteria to be followed for redevelopment of pre existing wells will be

- The removal of sediment inside the well
- If the accumulated sediments cannot be removed the goal of redevelopment will be to obtain stable field parameters (i e consecutive measurements of temperatures that are within 1°C pH readings within 0 2 units and conductivity within 10 percent) after removing three well casing volumes
- If the above results cannot be obtained, five well casing volumes will be removed and redevelopment stopped

5 0 DOCUMENTATION

The following well development information will be recorded on the Well Development and Sampling Form (Form PRO 106A) for newly installed wells or redevelopment of preexisting wells

- Well or piezometer I D and location survey coordinates
- Date(s) and time of well development
- Well designation
- Static water level from measuring point
- Total depth from measuring point
- Calculated well casing volume
- Quantity of water lost during drilling (if applicable)
- Quantity of water added during development
- Depth from top of well casing to top of sediment inside well before and after development
- Development method

- Field measurements of pH, specific conductance (SC), turbidity, and temperature taken at full casing volumes or more frequently if desired
- Physical description of removed water throughout development (color and odor)
- Quantity of water removed (incremental and total values)

6.0 REFERENCES

6 1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA
Interim Final October 1988

RCRA Facility Investigation Guidance Interim Final May 1989

RCRA Groundwater Monitoring Technical Enforcement Guidance Document.
EPA OSWER-9950 1 September 1986

6 2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are as follows

- SOP RMRS/OPS-PRO 118, Monitoring Well and Piezometer Installation
- SOP RMRS/OPS-PRO 127, Field Decontamination Operations
- SOP RMRS/OPS-PRO 128 Handling of Purge and Development Water
- SOP FO 15, Photoionization Detectors and Flame Ionization Detectors
- SOP FO 16, Field Radiological Measurements
- SOP RMRS/OPS-PRO 105, Water Level Measurements in Wells and Piezometers
- SOP RMRS/OPS-PRO 108, Measurement of Groundwater Field Parameters

ROCKY FLATS DEVELOPMENT/REDEVELOPMENT LOG FORM PRO 106A

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PROJECT NAME ____________ DATE(S) ________ ________ ________
SAMPLE NUMBER ____________ SUB-CONTRACTOR ____________
LOCATION CODE ____________ SAMPLE TEAM MEMBER ____________
GRID LOCATION ____________ MEMBER(S) ________ ________
WELL TYPE ____________ QA/QC BY ____________

Equipment Type	Equipment Identification	Standard Used	Temp (C)	Equipment Reading	Reading Acceptable?	Date	Time

Air Monitoring	Background	Well Bore	Headspace	Other ________	Comments
Day 1					
Day 2					
Day 3					
Day 4					

DEVELOPMENT VOLUME CALCULATIONS Checked by (initials) ________

DATUM TOP OF WELL CASING (TOWC) Purge Dates ________ ________ ________
ID = Well Casing Inside Diameter = ____________ Unit Casing Volume (☐ GAL or ☐ ML / Linear Foot) = ________ (UV)
Depth to Water (Feet) = ____________ (WD)
Measured Total Depth (MTD) ________ + Probe End (Feet) ________ = Total Depth (Feet) ________ (TD)
TD ________ WD ________ = Initial Water Column (Feet) ________ (IC)
UV ________ x IC ________ = Initial Water Volume (☐ GAL or ☐ ML) ________ (IV)
Quantity of Water Added During Development (☐ GAL or ☐ ML) = ________ (QWA)
(5 x IV ________) + (2 x QWA ________) = Development Volume (☐ GAL or ☐ ML) = ________ (DV)

If TD increases after first visit, recalculate IC IV and DV by using the initial WD and the deepest TD
Use this new DV to develop the well

2ND VISIT TD = Measured Total Depth (MTD) ________ + Probe End (Feet) ________ = Total Depth (Feet) ________
IC = TD ______ WD ______ = ________ IV = UV ______ x IC ______ = (☐ GAL or ☐ ML) ________
DV = (5 x IV ________) + (2 x QWA ________) = Development Volume (☐ GAL or ☐ ML) = ________

3RD VISIT TD = Measured Total Depth (MTD) ________ + Probe End (Feet) ________ = Total Depth (Feet) ________
IC = TD ______ WD ______ = ________ IV = UV ______ x IC ______ = (☐ GAL or ☐ ML) ________
DV = (5 x IV ________) + (2 x QWA ________) = Development Volume (☐ GAL or ☐ ML) = ________

Final MTD ________ + Probe End ________ = Final TD ________

Does the well dewater? ☐ YES or ☐ NO If Yes perform recharge rate calculation If no develop using DV
Actual Developed Volume (1st Visit) = ______ Units ______ Actual Developed Volume (3rd Visit) = ______ Units ______
Actual Developed Volume (2nd Visit) = ______ Units ______ Actual Developed Volume (4th Visit) = ______ Units ______
Total Developed Volume = ________ Units ________

RECHARGE RATE CALCULATIONS
(Use the IC and TD corresponding to the deepest TD measured to date)

9 x IC ________ = ________ 90% of initial water column 10 minute water recovery start time ______ end time ______
TD ________ (10 minute water depth ______ x 3 = ______) = ER = Estimated 30 Minute Recharge
9 x IC ________ = ________ 90% of initial water column 10 minute water recovery start time ______ end time ______
TD ________ (10 minute water depth ______ x 3 = ______) = ER = Estimated 30 Minute Recharge
9 x IC ________ = ________ 90% of initial water column 10 minute water recovery start time ______ end time ______
TD ________ (10 minute water depth ______ x 3 = ______) = ER = Estimated 30 Minute Recharge
9 x IC ________ = ________ 90% of initial water column 10 minute water recovery start time ______ end time ______
TD ________ (10 minute water depth ______ x 3 = ______) = ER = Estimated 30 Minute Recharge

 Quarterly records ________ of ________

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FORM 106A

LOCATION CODE _____

SAMPLE TEAM MEMBERS _____ _____ _____

Development Method – Type Used ☐ Bailer (☐ Teflon or ☐ SS) ☐ Peristaltic Pump ☐ Other _____

DEVELOPMENT VOLUMES AND FIELD WATER QUALITY MEASUREMENTS

Date (MM/DD/YY)	Time (24 Hour)	Volume Purged (☐ GAL or ☐ ML)	Temp (C)	Specific Cond (☐ mS/cm or ☐ µS/cm)	pH (SU)	Turbidity (☐ FTU or ☐ NTU)	Water Description (Color Odor)

ALKALINITY DETERMINATION _____

pH Offscale ☐ YES or ☐ NO pH Offscale Reading = _____ Checked by (initials) _____

If YES – At _____ pH Total Alkalinity = _____ x 10 = _____ ppm

If NO— At _____ pH Total Alkalinity (full range)= _____ ppm

Completed By (Print Name) _____ Signature _____ Date _____

Checked By (Print Name) _____ Signature _____ Date _____